

HERD IDENTITY AND CALVING GROUND
FIDELITY OF CARIBOU
IN THE KEEWATIN DISTRICT
OF THE NORTHWEST TERRITORIES



Northwest
Territories Renewable Resources



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YELLOWKNIFE, NWT

1992



File Report No. 101

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ABSTRACT

A caribou herd is defined as a group of animals that calve in the same location each year. Periodic dispersal of large numbers of caribou between herds has been suggested as a driving force in caribou population dynamics, but studies of marked animals in Alaska have documented only limited movement between herds. Recent increases in the Kaminuriak and Bathurst caribou herds indicated that massive immigration may have been partly responsible.

In order to document distribution at calving and fidelity to calving location, we radio-collared 62 cows on the range of the Kaminuriak and Northeastern Mainland caribou herds, between November 1984 and June 1985. We collared 40 more caribou before June 1986 and 10 more before June 1987. We flew over the entire District of Keewatin listening for radio collars each June between 1985 and 1988 in an attempt to locate each collared cow.

The distribution at calving was such that 3% of Kaminuriak cows (range 0-5%/yr) would not have been included within a calving ground defined using standard survey techniques. At Wager Bay, the proportion of cows calving in peripheral areas averaged 9% (range 0-13%/yr). Moreover, Wager Bay cows calved at lower densities and the location of the highest density calving areas varied more between years. We concluded that standard calving ground survey techniques adequately defined the Kaminuriak calving ground but failed to do so at Wager Bay.

We considered a cow to be unfaithful to its calving location when its calving location differed by at least 90km between years. In 1986, 7 of 51 cows (14%) were unfaithful to their 1986 calving location. Eight of 50 (16%) were unfaithful in 1987 and 8 of 54 cows (15%) were unfaithful in 1988. On average, 85% of cows return to the same location each year to calve. In 19 of the 23 instances where calving location changed between years the cow went from calving in the core of the calving ground to calving in a peripheral location or the other way around. In the other 4 instances, 3.6% of all fidelity tests, cows moved between recognized calving grounds.

Between 1985 and 1988 the combined effects of changes in calving location (4%) and calving ground survey bias (i.e., excluding between 3 and 13% of the cows from the census zone) were much less than the change in the number of cows on the Kaminuriak herd's calving ground between 1980 and 1982 (315%). Therefore the data do not support the suggestion that immigration contributed substantially to that increase. However, our observations describe caribou behaviour only between 1985 and 1988 and do not eliminate the possibility that large scale dispersal contributed to changes in the number of animals on the Kaminuriak calving ground in past years.

Because calving site fidelity was high and similar to what has been observed elsewhere, the Kaminuriak and Northeastern Mainland caribou herds appear to be discrete and there is no reason to reject the concept of herd definition based on calving grounds.

The calving ground concept suggests that Lorillard and Wager Bay must be considered one herd but movements throughout all of the northeastern mainland are still too poorly known to be able to differentiate subpopulations.

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INTRODUCTION

The subject of herd identity and calving ground fidelity has received considerable attention from management, ecological and evolutionary perspectives. Interest in these topics has increased because of; 1) mounting evidence that caribou may select different areas for calving over time (Gauthier 1984, Brown and Theberge 1985, Patten 1985, Pegau 1985, Davis et al. 1986, Brown et al. 1986, Heard and Calef 1986, Valkenburg and Davis 1986a), 2) heightened concern to identify calving areas so they can be protected from disturbance (Pare and Huot 1985; Whitten et al. 1984, 1985; Valkenburg and Davis 1986a), 3) critical evaluation of management and census procedures dependent on herd discreteness, calving ground and post-calving area fidelity assumptions (Davis et al. 1982, Heard 1985, Cameron et al. 1986, Valkenburg and Davis 1986a), 4) the importance of calving strategies and dispersal to population dynamics (Skoog 1968; Haber and Walters 1980; Bergerud 1974, 1980, 1983; Bergerud et al. 1984; Bergerud and Page 1987) and 5) the potential for construction of conceptual models of caribou sociobiology (Bergerud 1974, Davis et al. 1986).

Skoog (1968) defined a caribou herd as a group of animals that calve in the same location each year. Thomas (1969) named four caribou herds in the Northwest Territories (Bluenose, Bathurst, Beverly and Kaminuriak) (Figure 1) on the basis of their consistent use of the calving grounds defined by Kelsall (1968). Ear tagging studies (Heard 1983) and direct observations of caribou movements

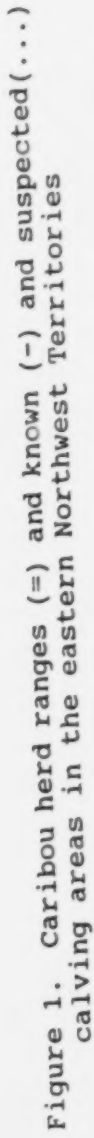


Figure 1. Caribou herd ranges (=) and known (-) and suspected(...) calving areas in the eastern Northwest Territories

(Kelsall 1968, Thomas 1969) indicated that the animals associated with each of those calving grounds occupied primarily separate ranges year round, but with some winter range overlap. Attempts to monitor the size of those herds have been based on estimates of caribou numbers on calving grounds (Heard 1985).

Based on Skoog's (1968) herd definition and their 1976 observations, Calef and Heard (1980) called the caribou calving south of Wager Bay the Lorillard herd, those calving north of Wager Bay the Wager herd and caribou calving on Melville Peninsula the Melville herd. Because similar densities of calving caribou were not found in subsequent years (Donaldson 1981, C. Gates pers. comm., Heard unpublished) uncertainty about herd discreteness led to the designation of the Northeastern Mainland herd for all caribou throughout that region (Heard et al. 1986).

The interpretation of calving ground estimates is based on the assumption that all cows in the herd return to the same area every year to calve. That assumption has never been tested in the Northwest Territories (NWT). Skoog (1968) suggested that periodic dispersal of large numbers of caribou between herds probably occurred but subsequent studies of marked animals in Alaska have never documented such movements (Davis et al. 1986, Patten 1985, Pegau 1985, Valkenburg and Davis 1986a). Ear tag returns of Beverly and Kaminuriak caribou suggested that emigration was less than 3% per year (Heard 1983). Heard and Calef (1986) suggested that recent increases in the Kaminuriak and Bathurst herds may have been partly due to massive immigration.

Because of the importance of calving ground surveys to caribou management in the Northwest Territories and because of the large changes in the Kaminuriak and Bathurst calving ground estimates between years we felt it was necessary to test the critical assumptions associated with calving ground survey methods (Heard 1985).

This study addresses the following hypotheses. 1) H_0 : All calving caribou are included within the census zone as defined using standard calving ground survey techniques. This hypothesis can be rejected by locating one or more cows outside the census zone in any year. 2) H_0 : Individual cows return to the same place each year to calve regardless of where they spent the remainder of the year. This hypothesis can be rejected if one cow, or more, is located with a calf so far from where she calved in any previous year that she would not have been considered part of the same herd of calving caribou in both years based on standard survey techniques. One observation contrary to our null hypothesis constitutes disproof, but we felt that calving ground survey assumptions would be grossly violated only if the behaviour of at least 5% of the animals in a single year did not conform with our predictions.

Regardless of the outcome of this study, we knew that our data would not determine if large scale dispersal had contributed to changes in the number of animals on the Kaminuriak and Bathurst calving grounds in past years.

METHODS

We radio-collared 112 female caribou between November 1984 and October 1986 (Table 1). All caribou were captured by shooting a hand held or skid mounted net (Margo Supplies Ltd., Calgary, Alberta) from a Bell 206B helicopter. We attempted to catch only adults but some of the animals may have been yearlings. To reduce trauma to the caribou we did not pull a tooth to determine exact age. In November 1984, we sedated all 9 animals with 30 mg of Rompun (Xylazine Hydrochloride), all but one other caribou were handled without drugs. All but two animals were instrumented with radio-collars made by Telonics (Mesa, Arizona). Cows #105 and 106 carried collars made by Lotek (Aurora, Ontario). Each radio-collar transmitted on a different frequency and had a coloured cover usually with a black number or alphanumeric to allow visual identification of collared animals. When possible, blood samples from caribou caught in November 1984, May 1985 and April 1985 and 1986 were used to determine progesterone levels as an indication of pregnancy (B.C. Bio-Medical Laboratories Ltd., New Westminster, British Columbia). We considered plasma progesterone levels over 2.5 ng/ml an indication of pregnancy (Rehbinder et al. 1981).

We attempted to find all instrumented caribou each June from 1985 through 1988, to determine whether or not each was accompanied by a calf and to describe the relative density and composition of caribou associated with each radio-collared cow. Radio-tracking was accomplished from four aircraft: Beechcraft Tradewind,

Table 1. Date, location and number of caribou radio collared between November 1984 and October 1986

Date	Location	Number collared
November 1984	Eskimo Point	9
April 1985	Eskimo Point	30
May 1985	Baker Lake	1
May 1985	Lorillard River	22
November 1985	Wager Bay	25
December 1985	Eskimo Point	3
April 1986	Eskimo Point	12
October 1986	Chesterfield Inlet	10
Total		112

Beechcraft Queen Air, DeHavilland Beaver and Bell 206B. Each plane was equipped with two H-element antennas (Telonics, Mesa, Arizona). The majority of radio relocations were made from the Tradewind and the Queen Air because their high speed and long range allowed large areas to be surveyed efficiently.

The "core" of the calving ground was defined as an area where there was a continuous distribution of calving cows occurring at relatively high densities. In 1985 and 1988 the core of the Kaminuriak calving ground was defined using standard procedures (Heard 1985) independent of the location of collared cows. Core Kaminuriak calving areas in 1986 and 1987 and for all four years at Wager Bay were based on the location of collared cows and incidental observations of uncollared animals.

RESULTS

Progesterone levels

Progesterone levels in 3 of the 46 caribou sampled in April and May 1985 ranged between 0.1 and 0.8 ng/ml and the animals were considered not pregnant. Progesterone levels in 43 cows ranged between 2.5 and 9.6 ng/ml indicating pregnancy. Two samples were analyzed twice to check on the accuracy of the technique. Repeatability was not impressive as sample #55 was measured at 0.3 and 0.7 ng/ml and #38 at 3.0 and 5.4 ng/ml, but the large separation between the progesterone concentrations in pregnant and nonpregnant animals is probably great enough to overcome the problem of measurement errors.

June 1985

We located all 62 collared caribou in June 1985 (Table 2). Two (#44 and 55) were far from calving areas but neither had a calf nor were they associated with other calving caribou. All but one of the other 60 cows would have been included within the boundaries of a calving ground census zone defined using traditional methods; 36 were on the Kaminuriak herd's calving ground, two (#25 and 43) calved north of Beverly Lake and would have been included in a census of the Beverly herd and 21 calved south of Wager Bay (Table 3, Figure 2). The one animal (#2) that would not have been

Table 2. Relocation of caribou in June 1985, 1986 and 1987

Year	Found	Not found	Known dead	Total available
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Caribou cohort collared Nov 1984-May 1985

1985	62	0	0	62
1986	50	2	10	62
1987	27	15 ^a	10	52
1988	29	7	6	42

Caribou cohort collared Nov 1985- Apr 1986

1986	36	3	1	40
1987	24	6 ^b	9	39
1988	22	1	7	30

Caribou cohort collared Oct 1986

1987	4	3	3	10
1988	3	2	2	7

^a 5 were found in Kaminuriak post-calving aggregations in 1987^b 2 were found in Kaminuriak post-calving aggregations in 1987

Table 3. Number of collared cows located each year on each recognized calving ground and in peripheral areas.

Calving ground	Year				Totals
	1985	1986	1987	1988	
Kaminuriak core	36	42	27	26	131
Kaminuriak peripheral (%)	1(3)	1(5)	1(4)	0(0)	3(3)
Wager core	21	34	21	21	87
Wager peripheral	2 ^a (0)	6(13)	3(13)	2(9)	13 ^a (9)
Melville core	0	2	2	2	
Beverly core	2	1	1	3	
Totals	62	86	55	54	
Unfaithful	-	7	8	8	

^a not pregnant

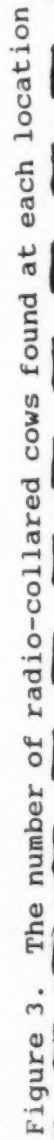
Figure 2. The number of radio-collared cows found at each location in June 1985

included in a calving ground census calved at Carr Lake, 130 km south of the core Kaminuriak calving area which was at Kaminuriak Lake. She was seen with a calf and was associated with about 20 barren cows, yearlings and bulls and at least one other cow-calf pair.

June 1986

We located 86 radio-collared caribou alive in June 1986, 50 of the 62 found in June 1985 and 36 of 40 collared after June 1985 (Table 2). Eleven radio-collared caribou were known to have died between June 1985 and June 1986. Wolves apparently killed #23 (S. Kearney pers. comm.) and #1 was shot. No attempt was made to determine the cause of death for the remainder. Five of 102 collared caribou (5%) were not found in June 1986.

Seven collared cows (10%) would have been excluded from any censused area in 1986 (Figure 3). Cows #24 and 27 would have been excluded from a Kaminuriak calving ground census because they were over 100 km from the centre of the calving ground (where there were 42 collared cows) and at least 50 km from the next nearest radio-collared caribou, but both were with small numbers (50-100) of cows and calves. Cow #27 was last seen on 28 May 1986 and could have moved to the core calving area by the peak of calving in early June but we assumed that she did not because we never heard her signal during subsequent flights over the calving ground. It is unlikely that animals #49, 59, 64, 66 and 67 would have been included in a



calving ground defined around Wager Bay where there were 34 collared cows. Cows #72 and 85 would have been included in a census of the Melville Peninsula calving ground. Number 72 was with about 20 cows and calves and #85 was in a group of about 10 cows and calves with at least six other small groups of cows and calves in the immediate vicinity.

The delineation of a Kaminuriak calving ground would have been more accurate than at Wager Bay with only 2 of 44 (5%) outside the Kaminuriak census zone vs 5 of 40 (13%) outside the Wager census zone (Table 3).

Of the 5 cows with atypical behaviour in 1985, #43 would again have been included in a census of the Beverly herd's calving ground, #25 was not found, #2 died between June 1985 and June 1986 and #44 and 55 calved in concentrations of calving caribou at Kaminuriak Lake and south of Wager Bay, respectively.

Most cows calved in the same general area in both 1985 and 1986 but south of Wager Bay the 1986 calving ground was slightly south and east of its 1985 location. Although cows #51 and 52 moved 80 km and 50 km, respectively, between years we still considered them faithful to their calving area because they remained within the calving concentration both years.

However, we rejected our second hypothesis that all individuals return to the same place each year to calve because in 1986, 7 of 48 (15%, 2 of the 20 found in 1985 had not borne calves in 1985) caribou calved at least 90 km from where they calved in 1985. We selected 90 km as a cutoff distance for fidelity after

examining calving locations. Cows were either much closer or much further than 90 km from their previous year's calving location. Cows #24 and 27 calved with the majority of the Kaminuriak herd in 1985 but they were 120 and 150 km from where they calved in 1985 and over 100 km from the centre of the Kaminuriak calving distribution in 1986. In 1986, #67 calved 90 km north of where she had calved in 1985 and #49, 59, 64 and 66 calved between 100 and 240 km southwest of their 1985 calving site.

All of the 7 cows unfaithful to their calving locations changed from calving in a major concentration to a peripheral low density location. No cows calved on more than one previously recognized calving ground (Figure 1).

June 1987

We located 55 collared cows in June 1987 (Table 2). We judged that only 4 would not have been included in a calving ground survey; one (#4) was south of the Kaminuriak calving ground, 2 (#48 and #49) were west of Wager Bay and #110 was northeast of Baker Lake (Table 3, Figure 4). Eight were considered unfaithful to their previous calving location.

Cow #4 was the only Kaminuriak animal that was unfaithful, being far south of the calving ground on 9 June. At Wager Bay cows #48 and 49 calved in a peripheral location in 1987 after being in the core area in 1986. Cow #66 calved peripherally in 1986 and in the core in 1987. Cows #51 and 76 calved with many other cows but

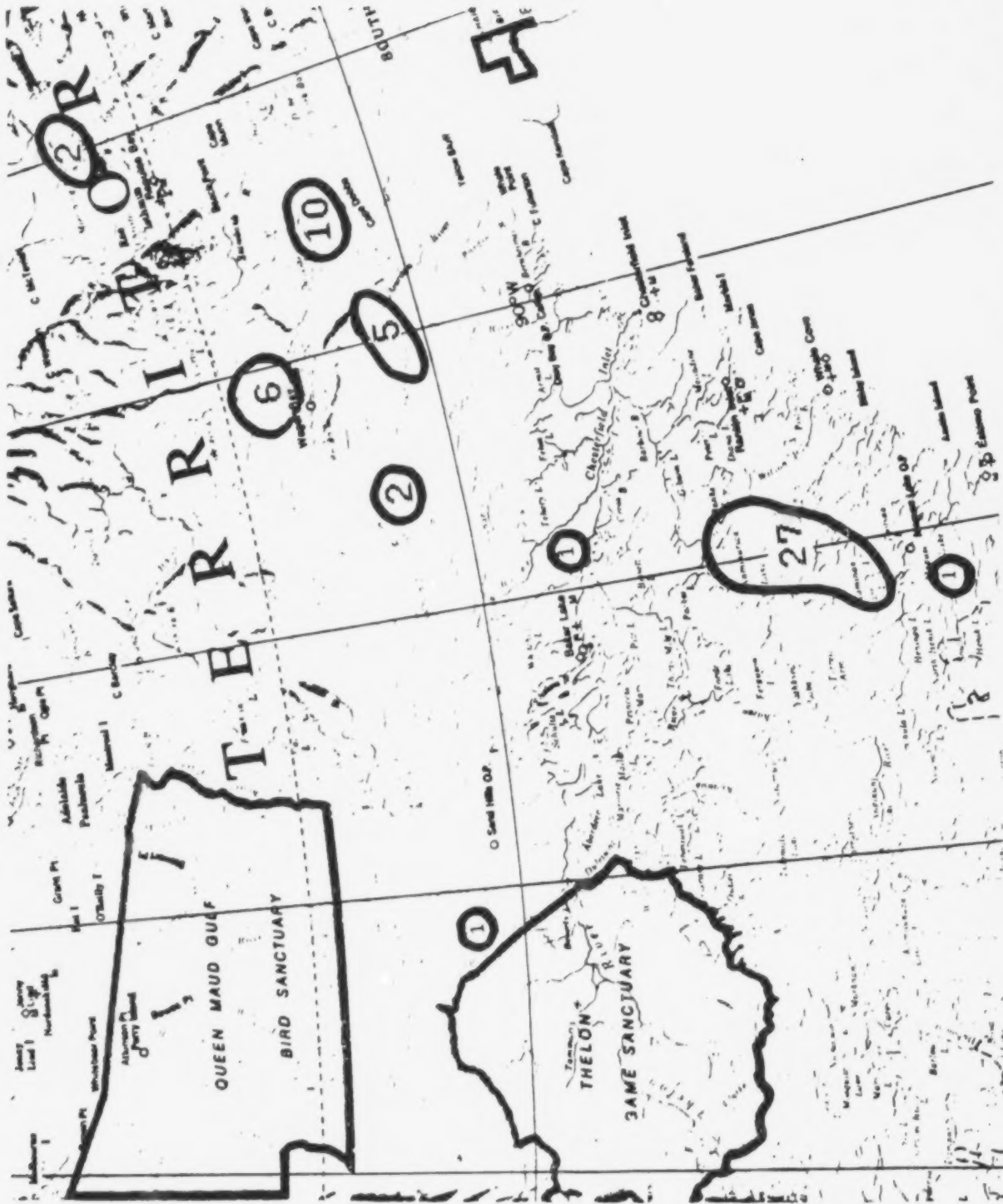


Figure 4. The number of radio-collared cows found at each location in June 1987

both moved about 90km between years. Cow #72 calved on Melville Peninsula in 1986 and at Wager Bay in 1987 and #91 calved at Wager Bay in 1986 and on Melville Peninsula in 1987.

Of the 4 (living) cows with atypical behaviour in 1985, #43 again calved at Beverly Lake, and #25, 44 and 55 were not found. Nine cows had atypical behaviour in 1986. Cows #24, 27, 64 and 85 were not found, #49 again calved peripherally, #66 moved to the core of the calving ground at Wager Bay, #59 moved only a short distance toward the core of the calving ground south of Wager Bay but because of the location of other cows was considered to have calved in the core rather than peripherally, #67 died and #72 moved to Wager Bay to calve.

As in 1986, more peripheral calving occurred around Wager Bay than around the Kaminuriak's calving ground (Table 3).

June 1988

We located 54 collared cows in June 1988 (Table 2). We judged that only 2 would not have been included in a calving ground census; one (#80) north of Wager Bay and one (#66) south of Wager Bay (Figure 5). No Kaminuriak cows calved peripherally.

Eight were unfaithful to their previous calving locations. In 1988, after three consecutive years of calving at Kaminuriak Lake, cow #30 calved at Sand Lake amid thousands of calving caribou from the Beverly herd. Cow #24 moved from a peripheral location in 1986 to the core in 1988 (she was not found in 1987), cows #48, 49 and

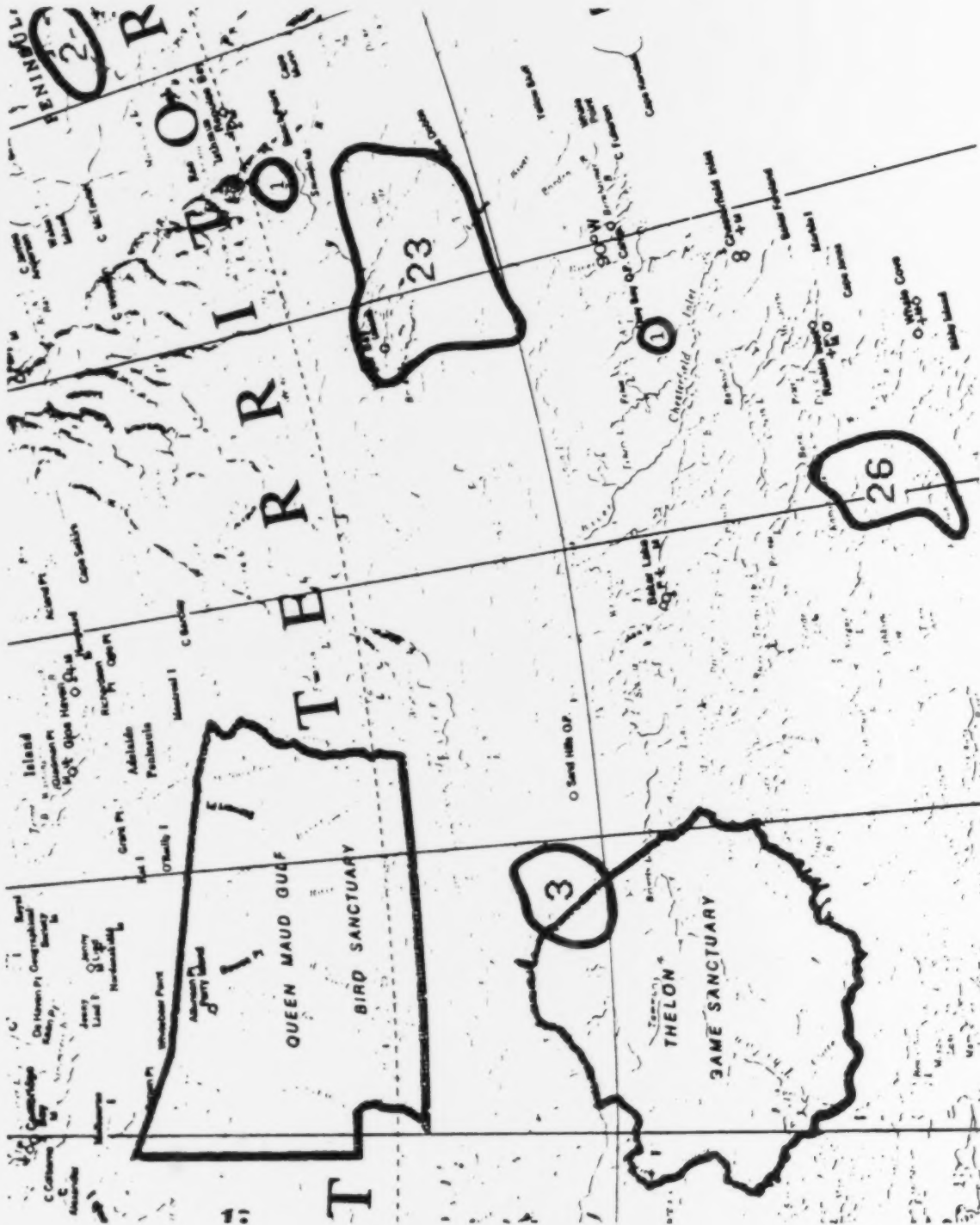


Figure 5. The number of radio-collared cows found at each location in June 1988

110 moved from peripheral locations in 1987 to the core in 1988, #66 and #80 moved from core to peripheral locations, #72 calved back on Melville Peninsula after calving at Wager Bay in 1987.

Of the 4 cows with atypical behaviour in 1985, #43 again calved at Beverly Lake, #25 was found calving at Beverly Lake after 2 years without being located, #44 was not found and #55 was found in the calving ground core at Wager Bay. Of the 8 cows with atypical behaviour in 1986, #24 was found in the calving core at Kaminuriak Lake, #27 was not found, #49 and 59 moved to the core calving area at Wager Bay, #64 died, #66 calved on the periphery of the Wager Bay calving ground, #72 moved back to Melville Peninsula where she calved in 1986 and #85 was found again on Melville Peninsula. Six cows had atypical behaviour in 1987. Cows #4 and 91 died before June 1988. Cow #48 moved from a peripheral to core calving area, #51 again calved in the Wager Bay calving core, #76 was not found and #110 moved to the calving core at Wager Bay.

Again more peripheral calving occurred at Wager Bay than at Kaminuriak Lake.

Four year summary

Twenty caribou were located in each of the 4 calving periods of this study and 32 were found only twice (Table 4). Thirty were located twice after their initial calving year but for 7 of those 30, there was at least one intervening year when they were not found.

Table 4. Frequency with which individual caribou were located in subsequent calving years

Number of locations		Number of caribou
Calving years	Subsequent yrs	
0	0	17
1	0	13
2	1	32 ^a
3	2	30 ^b
4	3	20
Total		112

a 6 occurred over 3 years e.g., the caribou was not found one year

b 7 occurred over 4 years

Of the 112 cows collared 17 were never located during calving and 13 were located only once during calving. The remaining 82 animals were located at least twice during calving. Cows that were located during two calving periods provided one test of calving area fidelity and if they were located three or four times they provided 2 and 3 tests, respectively. Thus the total number of calving fidelity tests was 152 ($32 + [2 \times 30] + [3 \times 20]$). Of those 82 animals 66 (80%) were always faithful to their previous calving location or conversely 20% showed a lack of calving fidelity at least once. Calving fidelity was demonstrated on 129 of the 152 tests (85%).

Nineteen of the 23 instances where calving locations changed between years involved a difference between calving locations of at least 90km and where the cow went from calving in the core of the calving ground to a peripheral location or the other way around. In the other 4 instances cows changed between recognized calving grounds. Cow #30 calved on the Kaminuriak herd's calving ground in 1985, 1986 and 1987 but in 1988 she was located at Sand Lake on the Beverly herd's calving ground. Cow #91 calved at Wager Bay and Melville Peninsula in 1986 and 1987, respectively. Cow #72 calved on Melville Peninsula in 1986 and 1988 and at Wager Bay in 1987.

There was only a slight tendency for cows to show calving fidelity to either the north or south side of Wager Bay but 12 of 34 cows (35%) located in more than 2 years calved on both sides of the bay. Between 1985 and 1986 2 of 20 cows (10%) switched sides

of the bay to calve, 11 of 20 (55%) switched between 1986 and 1987 and 1 of 14 (7%) switched between 1987 and 1988.

Mortality

Mortalities from netting were few. Four per cent of the 124 caribou netted (5 mortalities / [112 collared + 5 mortalities + 7 netted inadvertently and released uncollared]), died from injuries sustained during capture. Four died from broken necks and one was shot after breaking a leg. One animal died after being stalked and darted from a shooter on the ground and the technique was abandoned. We have no evidence that any animals died subsequently from capture myopathy. All but 5 caribou were known to be alive at least two months after having been captured. Only one of those was known to have died and it died 30 km from its capture site.

The mean annual mortality rate (p) was based on the binomial distribution such that $p = d/n$, where d = the number of animals dying during the year, n = the number of animals alive at the beginning of the year and the variance of $p = (p)(1-p)/n$.

Annual mortality of radio-collared caribou averaged 19%. Ten of 62 cows were known to have died between June 1985 and June 1986 (16% $sd=4.7$), 19 of 91 (21% $sd=4.2$) the next year and 15 of 79 (19% $sd=4.4$) between June 1987 and June 1988. Hunters shot 4 of those 48 caribou which was about 2% of the total mortality. Hunting mortality was expected to be about 2% per year given an estimated

kill of 2500-4000 Kaminuriak cows from a population of about 175,000 cows and a kill of about 1600 Wager Bay cows from a population of about 70,000 cows (Gamble 1987a,b; Heard and Calef 1986; Heard et al. 1986). At 17%/yr, the natural mortality rate of collared caribou was considerably higher than expected. Heard and Calef (1986) assumed that natural mortality in the Kaminuriak herd was in the range of 7%/year and natural mortality of cows was about 4-5%/yr where it has been measured in Alaska (Davis and Valkenburg 1985a,b). Specific causes of natural deaths were not determined during this study.

DISCUSSION

Calving ground fidelity was judged in a social as well as a spacial context. Cows giving birth within a major calving concentration area one year could be considered to be unfaithful if, in the next year, they calved; 1) in areas peripheral to the main calving concentration, or 2) within the calving concentration of another recognized herd. Cows were not considered to be unfaithful if they happened to have moved a considerable distance but stayed with the same group of caribou e.g., where the calving area of all cows changed among years (see below). Small shifts in the calving ground location of the entire herd is a common occurrence (Skoog 1968, Bergerud 1974, Fleck and Gunn 1982, Valkenburg and Davis 1986a). We did not consider calving ground shifts evidence of calving infidelity because such shifts do not conflict with Skoog's (1968) herd concept, they do not have implications to population dynamics, nor do they violate the assumptions of calving ground survey techniques. Such shifts are important when it comes to 1) defining calving areas for protection from industrial development and 2) except where adverse weather is involved (see Valkenburg and Davis 1986a:320), determining the mechanisms of how caribou find and recognize calving grounds and the evolutionary advantages of calving ground fidelity and 3) constructing models of caribou sociobiology.

Considering calving ground fidelity in both a social as well as a spacial context permitted us to decide that cow #67 was

unfaithful whereas #51 was faithful, even though the distances between their 1985 and 1986 calving locations were similar. In 1986, #67 calved 90 km north of where she calved in 1985 and #51 calved 80 km from where she calved in 1985 but she remained within a calving concentration.

We set out our first hypothesis assuming that if cows were not within the defined calving ground they would be peripheral to it either calving with other cows at low density or as part of a small concentration of calving cows. The worst case we envisaged was that more than 5% of cows would be overlooked using standard survey methods. Our results did not support our first hypothesis, but we concluded that standard calving ground survey techniques were adequate because only 3% of calving Kaminuriak caribou would be excluded from the census zone (Table 3). At Wager Bay, the proportion of cows calving in peripheral areas averaged 9% (0-13%/yr). Moreover, Wager cows calved at lower densities and the location of the highest density calving areas varied more between years. We concluded that standard calving ground survey techniques would not adequately define the calving ground at Wager Bay.

We have no explanation why cows were unfaithful to calving sites, nor why some cows calved far from the main calving concentrations. The most likely explanation for peripheral calving is that those cows were not pregnant. That was the case for cows #44 and 55 in 1985 but was not the case for #2 in 1985. Unfortunately we were unable to confirm the calving status of most cows because visibility was poor from the aircraft we were using.

This would have been a more serious problem if peripheral calving involved more animals.

At Wager Bay calving densities were lower, the location of the core calving areas varied more between years and there was a higher proportion of cows on the periphery than on the Kaminuriak herd's calving ground. The Wager herd was only one tenth the size of Kaminuriak herd (36,000 in 1983 vs 320,000 in 1985) and does not appear to undergo such long and predictable migrations (Heard and Calef 1986, Heard et al 1986). Possibly the Wager animals are, on average, adopting a different calving strategy (Bergerud and Page 1987); because calving and winter ranges are not widely separated, they are attempting to be less predictable and more dispersed at calving. This strategy would also be correlated with population size because migration distance correlates with herd numbers (Heard and Calef 1986).

Bergerud and Page (1987) suggested that small woodland caribou populations that do not migrate far from predators adopt a dispersed calving strategy in order to reduce the chance that their calf will be found by a predator. We suggest that the same arguments may apply to medium sized (e.g., Wager) caribou herds as well.

Conceptual models of caribou sociobiology (Bergerud 1974, Davis et al. 1986) are inadequate to explain exceptions to the general rule of calving area fidelity. Davis et al. (1986) suggested that different calving strategies may exist within one population. If so, we might expect the cows we considered

peripheral and unfaithful in one year to be overrepresented in the peripheral and unfaithful category in other years. This did not appear to be the case as cows were often found in core and peripheral areas in alternate years. Perhaps the two calving strategies that exist are 'variable' and 'core'; i.e., 'core' animals always calve in the core of the calving ground and 'variable' cows may calve peripherally or in the core. This hypothesis would be difficult to test directly but one could examine the reasons why a cow should pursue either of those strategies (e.g., social status, age, past reproductive success etc.).

We believe that 90 km is a reasonable minimum distance to demonstrate a change in calving locations among years. Davis et al. (1986) considered that the 10 (of 49) radio-collared Delta herd cows that calved on the Yanert herd calving ground in 1984, 70 km away to be a significant change in calving location. Brown and Theberge (1985) and Brown et al. (1986) considered only those cows whose calving sites were within 10 km showed calving area fidelity.

Our estimates of calving ground fidelity (80-85%) were within the range observed by others. Calving fidelity was over 88% in the Burwash herd (Gauthier 1984 cited in Davis et al. 1986) at least 63% in the Red Wine Mountains herd (Brown and Theberge 1985). Over 95% in the Caniapiscau herd and 82% in the Lac Joseph herd (Brown et al. 1986). Davis et al. (1986) said they found a mean calving fidelity of 96% in the Delta and Yanert herds based on almost 100% fidelity in all but one year when 20% (10 of 49) of the Delta herd

cows calved elsewhere. However, those 10 cows returned to the Delta herd the following year and were therefore again unfaithful to their previous year's calving area. Furthermore Davis et al. (1986) counted the first year a cow was observed on a calving ground as a "faithful" calving-ground-year whereas we began counting with the second year. When the above two changes were incorporated into the calculations, their mean calving ground fidelity dropped to about 88% (21 calving site changes in about 180 calving ground years). Neither the exact number of calving ground years, nor the number of cows that had born calves, could be calculated from the data in their paper. Bias resulting from some cows not having calves could be in either direction.

Our data support our second hypothesis that cows return to the same calving ground each year to calve. We recorded more than five "unfaithful" cows each year but only 1 cow in 1987 and 3 in 1988 would have been considered part of a different herd. Therefore, we see no reason to reject the traditional definition of caribou herds based on calving ground association.

Between 1985 and 1988 the combined effects of changes in calving location (4%) and calving ground survey bias (i.e., excluding between 3 and 13% of the cows from the census zone) were much less than the change in the number of cows on the Kaminuriak herd's calving ground between 1980 and 1982 (315%). Therefore the data do not support the suggestion that immigration contributed substantially to that increase. However, our observations describe caribou behaviour only between 1985 and 1988 and do not eliminate

the possibility that large scale dispersal contributed to changes in the number of animals on the Kaminuriak calving ground in past years.

Because calving site fidelity was high and similar to what has been observed elsewhere, the Kaminuriak and Northeastern Mainland caribou herds appear to be discrete and there is no reason to reject the concept of herd definition based on calving grounds. The calving ground concept suggests that Lorillard and Wager caribou must be considered one herd, but movements on the northeastern mainland are still too poorly known to be able to differentiate subpopulations.

ACKNOWLEDGEMENTS

We thank the Polar Continental Shelf Project and the Government of Manitoba's Department of Natural Resources for assisting the Department of Renewable Resources, Government of the Northwest Territories with the costs of this study. Pilots from Quasar Helicopters (Dan Cloutier, Mike Dorsey and Mark Hutcheson) and Keewatin Air (Paul McDougall, Kevin Bilquist and Rob Weldon) provided safe and skilful flying and Mark Williams, Robert Mulders, Ben Kovic, Nick Lunn, Carey Ogilvie and Larry Gray assisted in capturing and/or tracking caribou. Derek Melton reviewed the manuscript.

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LITERATURE CITED

- Bergerud, A.T. 1974. The role of environment in the aggregation, and disturbance behaviour of caribou. pp. 552-584. In V. Geist and F. Walther. (eds). The behaviour of ungulates in relation to management. International Union for Conservation of Nature and Natural Resources Publications new series No. 24. Morges, Switzerland. 942pp.
- Bergerud, A.T. 1980. Status of Rangifer in Canada: Woodland caribou Rangifer tarandus caribou. pp. 748-753. In E. Reimers, E. Gaare and S. Skjenneberg (eds). Proceedings of the Second International Reindeer/Caribou symposium. Direktoratet for vilt og ferskvannsfisk. Trondheim. 779pp.
- Bergerud, A.T. 1983. The natural population control of caribou. pp. 14-61. In F.L. Bunnell, D.S. Eastman, and J.M. Peek. (eds). Symposium on natural regulation of wildlife populations. Forest Wildlife and Range Experimental Station, University of Idaho. 225pp.
- Bergerud, A.T., H.E. Buttler, and D.R. Miller. 1984. Antipredator tactics of calving caribou: dispersion in mountains. Canadian Journal of Zoology. 62:1566-1575.
- Bergerud, A.T. and R.E. Page. 1987. Displacement and dispersion of parturient caribou at calving as antipredator tactics. Canadian Journal of Zoology 65: 1597-1606.
- Brown, W.K. and J.B. Theberge. 1985. The calving distribution and calving-area fidelity of a woodland caribou herd in Central Labrador. McGill Subarctic Research Papers. 40:57-68.
- Brown, W.K., J. Huot, P. Lamothe, S. Luttich, M. Pare, G. St. Martin and J.B. Theberge. 1986. The distribution and movement patterns of four woodland caribou herds in Quebec and Labrador. Rangifer Special Issue No. 1:43-49.
- Calef, G.W. and D.C. Heard. 1980. The status of three tundra wintering caribou herds in northeastern mainland Northwest Territories. pp. 582-594. In: Reimers, E., E. Gaare and S. Skjenneberg (Eds.). Proceedings of the Second International Reindeer/Caribou Symposium. Direktoratet for vilt og ferskvannsfisk. Trondheim. 779pp.
- Cameron, R.D., K.R. Whitten and W.T. Smith. 1986. Summer range fidelity of radio-collared caribou in Alaska's Central Arctic herd. Rangifer Special No. 1:51-55.

- Davis, J.L. and P. Valkenburg. 1985a. Demography of the Delta caribou herd under varying rates of natural mortality and harvest by humans. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Final Report. Projects W-21-2, W-22-1, W-22-2, W-22-3 and W-22-4. Juneau, Alaska. 50 pp.
- Davis, J.L. and P. Valkenburg. 1985b. Qualitative and quantitative aspects of natural mortality of the Western Arctic caribou herd. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Final Report. Projects W-17-11, W-21-2, W-22-1, W-22-2 and W-22-3. Juneau, Alaska. 71pp.
- Davis, J.L., P. Valkenburg and R.D. Boertje. 1982. Home range use, social structure, and habitat selection of the Western Arctic caribou herd. Final Research Report prepared for National Parks Service, Alaska Department of Fish and Game, Fairbanks. 87pp.
- Davis, J.L., P. Valkenburg and R.D. Boertje. 1986. Empirical and theoretical considerations toward a model for caribou socioecology. Rangifer Special Issue No. 1:103-109.
- Donaldson, J.L. 1981. Population and recruitment estimates for the Lorillard and Wager caribou herds in 1977. Indian and Northern Affairs Publication No. QS-8160-043-EE-AI, ESCOM Report No. AI-43, 50pp.
- Fleck, E.S. and A. Gunn. 1982. Characteristics of three barren-ground caribou calving grounds in the Northwest Territories. Northwest Territories Wildlife Service Progress Report No. 7 Yellowknife, NWT. 158pp.
- Gamble, R.L. 1987a. Native harvest of wildlife in the Keewatin region, Northwest Territories for the period October 1983 to September 1984. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1543. 82pp.
- Gamble, R.L. 1987b. Native harvest of wildlife in the Keewatin region, Northwest Territories for the period October 1984 to September 1985. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1544. 59pp.
- Gauthier, D.A. 1984. Population limitation in the Burwash caribou herd, southwest Yukon. Ph.D. thesis. University of Waterloo, Waterloo, Ontario. 247pp.
- Haber, G.C. and C.J. Walters. 1980. Dynamics of the Alaska-Yukon caribou herds and management implications. pp. 645-663. In: Reimers, E., E. Gaare and S. Skjennneberg (Eds.). Proceedings of the Second International Reindeer/Caribou Symposium. Direktoratet for vilt og ferskvannsfisk. Trondheim. 779pp.

- Heard, D.C. 1983. Hunting patterns and the distribution of the Beverly, Bathurst and Kaminuriak caribou herds based on tag returns. *Acta Zoologica Fennica* 175:145-147.
- Heard, D.C. 1985. Caribou census methods used in the Northwest Territories. *McGill Subarctic Research Papers*. 40:229-238.
- Heard, D.C. and G.W. Calef. 1986. Population dynamics of the Kaminuriak caribou herd, 1968-1985. *Rangifer Special Issue* No. 1:159-166.
- Heard, D.C., T.M. Williams and K. Jingfors. 1986. Precalving distribution and abundance of barren-ground caribou on the northeastern mainland of the Northwest Territories. *Arctic* 39:24-28.
- Kelsall, J.P. 1968. The migratory barren-ground caribou of Canada. *Can. Wildl. Serv. Monograph No. 3*. Queen's Printer, Ottawa. 340pp.
- Pare, M. and J. Huot. 1985. Seasonal movements of female caribou of the Caniapiscau Region, Quebec. *McGill Subarctic Research Papers*. 40:47-56.
- Patten, S. 1985. Game management unit: 18. pp 23-28. In A. Seward. (ed). Caribou survey-inventory progress report. Vol XVI. Federal Aid in Wildlife Restoration Project W-22-4. 56pp.
- Pegau, R.E. 1985. Game management unit: 19 and 21. pp 29-31. In A. Seward. (ed). Caribou survey-inventory progress report. Vol XVI. Federal Aid in Wildlife Restoration Project W-22-4. 56pp.
- Rehbinder, C., L.E. Edqvist, U. Riesten-Arhed and M. Nordivlist. 1981. Progesterone in pregnant and non-pregnant reindeer. *Acta Vet. Scand.* 22: 355-359.
- Skoog, R.O. 1968. Ecology of the caribou (Rangifer tarandus granti) in Alaska. Ph. D. Dissertation, University of California, Berkeley. 699pp.
- Thomas, D.C. 1969. Population estimates and distribution of barren-ground caribou in Mackenzie District, N.W.T., Saskatchewan and Alberta - March to May, 1967. *Canadian Wildlife Service Report Series*. No. 9., Ottawa. 44pp.
- Valkenburg, P. and J.L. Davis. 1986a. Calving distribution in Alaska's Steese-Fortymile herd: A case of infidelity? *Rangifer Special Issue* No. 1:315-323.

- Valkenburg, P. and J. L. Davis. 1986b. Population status of the Fortymile caribou herd and identification of limiting factors. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration Progress Report. Projects W-22-4 and W-22-5. Juneau, Alaska. 26pp.
- Whitten, K.R., G.W. Garner and F.J. Mauer. 1984. Calving distribution, initial productivity and neonatal mortality of the Porcupine Caribou herd, 1983. pp. 359-420. In G.W. Garner and P.E. Reynolds. (eds). 1983 update report baseline study of the fish, wildlife and their habitats. U.S. Fish and Wildlife Service. Anchorage, Alaska. 614pp.
- Whitten, K.R., G.W. Garner and F.J. Mauer. 1985. Calving distribution, initial productivity, and neonatal mortality of the Porcupine caribou herd, 1984. pp. 527-612. In G.W. Garner and P.E. Reynolds. (eds). 1984 update report baseline study of the fish, wildlife and their habitats. U.S. Fish and Wildlife Service. Anchorage, Alaska. 777pp.

